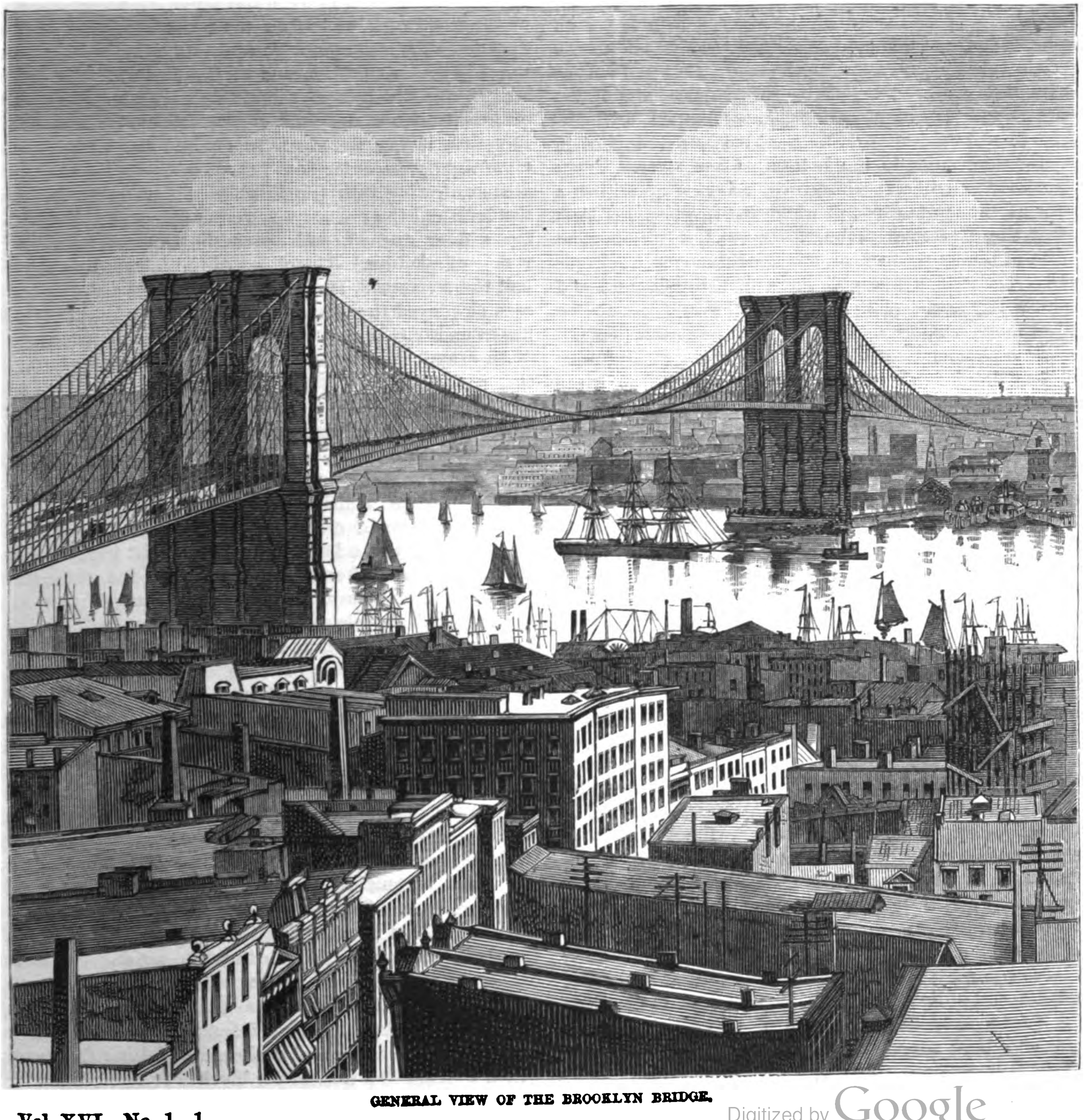
FRANK LESLIE'S POPULAR MONTHLY.

VOL. XVI., No. 1. JULY, 1883. $3.00 PER ANNUM.

THE LONGEST SPAN IN THE WORLD.

BY ARTHUR V. ABBOTT.

A LITTLE more than ten years ago the residents of Brooklyn were astonished at hearing, night after night, a curious puffing in the neighborhood of Fulton Ferry. It sounded as if some huge sea-monster had selected that spot as a resting-place, and, whale-like, was amusing himself by blowing. Those who inquired into the mystery found a remarkable amphibian, in the shape of an enormous wooden box turned upside down in the water,



GENERAL VIEW OF THE BROOKLYN BRIDGE.

bearing on its upturned bottom a number of steam-engines, which were busily engaged in pumping air into the box, and whose puffs were the mysterious blowing which had been heard. Many were satisfied with this solution. But those who desired further elucidation were informed that the great box was a caisson, and was destined to become the foundation for the massive tower of a bridge, the steel threads of which should, ere long, closely unite New York and Brooklyn.

A good foundation is of the greatest importance to every undertaking, and to none is it of more consequence than to a suspension bridge, the tops of whose lofty towers now support millions of lives. Nor is it an easy matter to secure a foundation for such a purpose. The graceful structure now spanning the East River is, indeed, most wonderful, but the hardest part of the work, wherein more obstacles were encountered, and more skill and courage displayed in surmounting them, lies seventy feet under the muddy water of the East River, and forgotten in the oblivion of a decade.

How to get a solid foundation was the first problem to be solved at the commencement of the bridge enterprise, and at once the query arose whether there might not be, under the mud and sand of the river, a firm ledge on which the tower could stand as solid as the Pyramids. To ascertain this the first work of the engineers was to cause a series of borings to be made on the proposed site of the tower. By means of a curious, auger-shaped drill, attached to a long iron rod, holes three or four inches in diameter were sunk in the bottom of the river. Every few inches the drill was withdrawn, bringing up with it a sample of the strata through which it was passing. Foot by foot the drill sank through the mud, till at last, at a depth of ninety-six feet, on the Brooklyn side, rock was found. To build a tower downward, through mud and water for 100 feet, and then upward through the air for 300 feet more, was deemed unwise, and so it was decided to adopt a plan successfully used in Europe, and, strange as it may seem, make a foundation of wood. To place a tower, weighing more than 100,000 tons, on a wooden structure, apparently subject to rapid decay, would seem to be the height of foolishness. Yet by making the foundation large enough, the pressure is distributed over so great an area as to be perfectly safe, and by sinking the woodwork deeply into the bottom of the river, the sand and gravel are washed over it to such an extent as to hermetically seal it away from the oxidizing action of the air, and preserve it indefinitely. Examples of such preservation may be seen in the fossil trunks of trees occasionally found in ancient river beds, where they have lain for countless ages.

Having satisfactorily decided the kind of foundation, the next problem was to place the woodwork in its proper situation. Dredging out an enormous hole for the timber would be impracticable, for the wash of the river would fill the hole up faster than the dredge could excavate it; while to build the foundation fifty feet under water would be equally impossible, on account of the difficulty of working at that depth, and the buoyancy of the material. Fortunately, it was possible to make the foundation dig its own hole, and sink in it at the same time.

To accomplish this an enormous wooden box, 168 feet long and 102 feet wide, was built. The peculiarity of the box—or caisson, as it is technically called—lies in the fact that it has a top, but no bottom. The top of the box, on which the tower of the bridge rests, is fifteen feet thick, of solid timber; the whole being bolted together in the strongest possible manner. The caisson was built at one of the shipyards of Greenpoint, and when completed was launched in much the same way as a ship. From the illustration of the caisson some idea of the great box may be obtained. The picture is copied from a photograph taken when the caisson was all completed, and just as it was ready to be launched. The launching weight of the structure was about 3,000 tons, and as soon as it was fairly in the water a fleet of tugs seized the queer vessel and towed it to its last resting-place near Fulton Ferry.

Previous to the arrival of the caisson, the site of the tower had been carefully dredged as smooth and level as possible, and a row of piles driven to guide the caisson to its place. As soon as the caisson reached the site, and was securely moored to the guiding-piles, the work of laying the masonry of the tower on the top of the box commenced. Every pound of stone there placed caused the box to sink deeper and deeper in the water, till at last the bottom, or shoe of the caisson, rested on the mud of the river. Then came the tug of war. On shore a number of steam-engines, working powerful air-compressors, had been placed, and as soon as the caisson touched bottom these pumps were set at work forcing air into the caisson through a series of pipes built into the roof. The effect of the air was to force the water out under the edge of the woodwork, and when the water had been entirely expelled a gang of men were sent into the caisson, passing through the roof by means of the air-lock. As will be seen by the illustration, the air-lock was a small chamber of iron built on the roof of the caisson. To enter the structure it was necessary to go into the air-lock, and close tightly the outer door; then, by opening a stop-cock communicating with the interior, the pressure between the lock and the caisson was gradually equalized, and the lower door opened, and access had to the interior by means of a ladder. To get out of the caisson this process had to be reversed, and so for many months the gangs of men employed there had to undergo this process of locking in and out, occupying from two to ten minutes.

An examination of an illustration showing a cross section of the caisson will give a very good idea of the structure, and the method of carrying on the excavation. As will be seen, the caisson was constructed so as to have an immensely thick roof, covering a small space sufficiently high to allow men to work beneath the roof. The sides of the box were furnished with a sharp shoe, made of iron, for the purpose of cutting through the mud and sand. In the centre was a large tube of wrought iron, reaching to the bottom of the caisson, and called the water-shaft. The method of excavation was this: A gang of men with pickaxes and shovels went into the caisson and loosened as far as possible the mud and sand, another set shoveled them under the bottom of the shaft; a dredge, operated by a derrick placed on the top of the caisson, descended through the shaft, and hoisting the excavated material up, deposited it in a scow to be carried away. These operations will be quite clearly comprehended by an examination of the illustrations of the interior of the caisson.

In order to keep the compressed air in the caisson it was necessary to exercise great care to keep the water-shaft constantly full of water, which, acting like the mercury in a barometer-tube, always exactly balanced the water pressure. On one occasion the supply of water in the shaft of the Brooklyn caisson became too small, and the shaft "blew out." Unfortunately, no one was in the caisson at the time, so that experience is lost. Eye-witnesses outside state that water, fog, mud and stones in a dense column were thrown 500 feet into the air, accompanied by a terrific roar and a shower of falling fragments, which covered the houses for blocks around. The noise was so frightful that the whole neighborhood was stam-

peded, and made a rush up Fulton Street. Even the toll collectors at the ferry abandoned their tills. The watchman on the caisson reports that the current of air rushing toward the shaft was so strong as to knock him down, and a blow from a falling stone then rendered him unconscious. In a moment or two all was over, and the doors of the air-lock dropping open, rendered the dry bottom of the river visible through both air-lock and water-shaft. Fortunately the caisson was amply strong enough to stand the enormous pressure which thus suddenly came upon it, so that no damage was done, and when, in a few hours, the steam-pumps had restored the supply of air and water, all the essential parts were found uninjured.

As fast as the material was excavated the caisson sank through the river bottom, until at last, at a depth of forty-five feet, a sufficiently compact stratum was reached to support the weight of the bridge. Then came the task of filling up the space that had been arranged for the workmen with cement and concrete, so as to make a perfectly solid mass to carry the tower.

Such, briefly, is the history of the Brooklyn foundation; and, with the exception that the caisson on the New York side was carried down to bed rock at a depth of seventy-eight feet, its story is much the same.

While one set of men had been burrowing, mole-like, under ground, or, rather, under water, and sinking the caisson through the mud, another set had been busily engaged in piling stone on the top of the box, thus helping by its weight to sink the foundation, and at the same time to build the tower; so that when the caisson reached its final resting-place, the mason-work of the tower stood just above the water like a little granite island. Then came many months of patient work, monotonous, perhaps, to the public, who saw nothing remarkable in the slow growth of the tower, except that the masonry was ponderous in the extreme, and that great care was necessary to lift the huge blocks two or three hundred feet into the air, yet a positive relief to the engineers, who had for so long been resisting, in the dismal darkness of the caisson, the insidious attacks of the river. Layer after layer of toughest granite rose in the air by month after month of patient labor, till, in 1875, there stood erect, one on each side of the river, two towers, the graceful arches of which, like the shoulders of old Atlas, were fit to sustain a little world, and ready for the steel strands of the coming bridge. A very good idea of the towers as they thus stood, some six or seven years ago, may be had from the illustration of "The Bridge in 1875."

While the towers had been in process of construction, two other pieces of masonry, equally important to the success of the bridge, though perhaps not so imposing in appearance, had been commenced and carried nearly to completion. These pieces of masonry were the anchorages. A suspension bridge is simply a bridge that is hung or suspended from cables stretched from shore to shore over the rivere which it is desired to cross. Of course, all the weight of the bridge and load is carried by the cables, and the ends of each cable must be fastened on either side so securely as to be perfectly safe against pulling out; for, should this happen, the bridge and all its load would drop into the water. In cases where rock ledges are to be found on the shores, the anchoring of the ends of the cables is generally an easy matter, it being simply necessary to secure the ends of the cables to the rock. In the case of the East River Bridge, as has already been seen, no rock could be found. It was, therefore, necessary to manufacture artificial ledges large enough to resist by their dead weight the pull of the cables. Two sites were therefore selected on either shore, in a direct line with the two towers, and about 900 feet away from them. On each of these sites an enormous pile of granite masonry was erected, about 129 feet long, 119 feet wide, and 90 feet high.

The picture of "The Foundation of the Anchorage" will give a good idea of the size of the masonry at the base of the anchorage, and also the method of attaching the cables. In the foreground of the illustration will be seen four large cast-iron plates; these plates are called "anchor-plates," and are placed at the very bottom of the anchorage. All the rest of the masonry is piled on top of them. In the centre of each plate a series of iron bars, or links, is placed, extending upward through the stonework and emerging on the top of the anchorage. By reference to a picture of "The Anchor Bars" this contrivance will be best understood. The cable is secured to this chain of bars, and, in order to break loose, the cable must either break the chain, or else pull the anchorage bodily up and out of the ground. Having thus completed the towers and the anchorages, the next and possibly the most important part of the work was the construction of the cables.

To a suspension bridge the cables are as important as is the keystone to an arch, for from them, suspended by rods or ropes, hangs the entire structure with its living load. The East River bridge, with its unprecedented span of 1,600 feet, its roadway of eighty-five feet, supporting the traffic of two such cities as New York and Brooklyn, placed in one of the most exposed situations possible, constantly subjected to the fierce gales of the Atlantic coast, and the corroding action of the sea air, required for its cables the use of the strongest possible material, selected with the greatest care, and laid in place with all the skill of which modern engineering is capable. To the engineer of to-day there would not be even a question as to the use of steel for such a purpose, for now steel is rapidly displacing iron for all structural uses, but ten years ago grave doubts were entertained by many good authorities as to the possibility of obtaining steel of the requisite quality and uniformity for such a purpose.

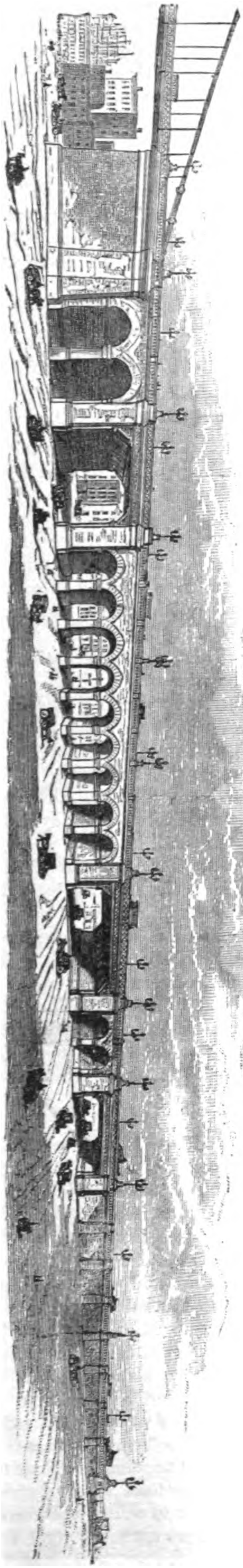
A bar of good wrought iron one inch in section, will require a force of about 50,000 pounds to break it. By drawing the same bar into wire about the size of a lead pencil, its particles are so compacted and hardened as to require a force of 70,000 or 80,000 pounds per square inch to cause rupture. Under similar treatment it is found possible to make steel wire capable of standing 200,000 or 300,000 pounds to the square inch. This strong wire would be exceedingly useful in bridge building, were it not for the fact that it is very brittle, and under a slight shock would snap like glass. After much experimenting it was found possible to obtain from the wire makers a very good quality of steel wire, having a breaking strain of 160,000 pounds to the square inch, and sufficiently elastic to be perfectly free from the danger of breaking by sudden shocks. Accordingly, in the Fall of 1876, a contract was made with the Eagle Wire Works of Brooklyn, to supply about 3,400 tons of steel wire nearly as large as a slate pencil. The wire was made in coils of 800 feet in length, and as fast as it was completed the wire ran through a bath of melted zinc so as to galvanize it, and thoroughly protected it from the weather. In order to insure that the specified quality of the wire was maintained, inspectors were placed at the manufactory, who rigidly examined each ring before it was sent to the bridge. As soon as the wire came out of the zinc bath, an examination was made to see if it was thoroughly covered with zinc, and that there were no lumps or rough spots. If this investigation was satisfactory the coil was passed to the next inspector, who cut off a piece,

VIEW ON THE COMPLETION OF THE TOWERS.

and placing it in a testing machine, pulled it apart, carefully noting the force required to break it, and the amount that the piece stretched. If these were found correct, the coil was accepted and sent to the bridge, or if not, the wire was returned to the manufacturer.

Meanwhile preparations for cable-making at the bridge had been rapidly progressing. On the top of the Brooklyn anchorage a large shed had been built, and a number of reels or drums, each capable of holding several miles of wire, set in place, ready to be filled with wire. In addition to the galvanizing, it was decided to give the wire three coats of oil, so in the yard around the anchorage large tanks were built, wherein to dip the wire, and a number of racks set up on which the wire could be hung to dry.

Of all the preparations for cable-building, the construction of the foot bridge was perhaps the most interesting. It is obvious that in a cable composed of many thousands of parallel wires it is very necessary that each wire should be carefully adjusted to receive its fair proportion of the whole load; otherwise some wires would have no weight to bear, while others would have more than their proportion, and becoming overtaxed, would break, and thus soon the whole cable be destroyed. In order to regulate the wires, as it is technically called, it was necessary to have access to the cables at five points, three in the centre span, and

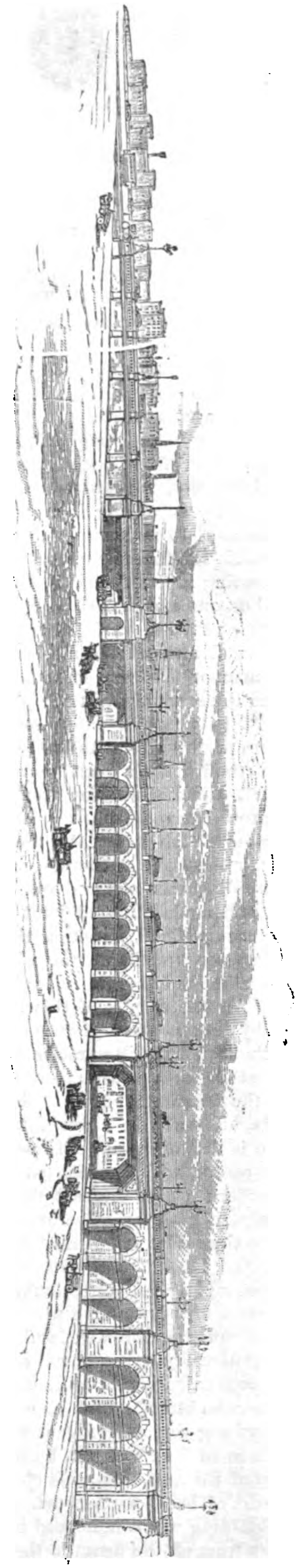


THE BROOKLYN APPROACH.

one in each of the land spans; and the easiest way to accomplish this was to construct a temporary bridge, so arranged as to allow of easy access to the cables at all points. As the foot-bridge was only for the convenience of the workmen during the process of cable-making, it was simply essential to make it strong enough to outlast that operation, and a structure built of oak slats laid on wire ropes, stretched from tower to tower, was all that was required. The first thing to be done was to get a rope across the river, so a sufficient quantity of three-quarter inch wire rope was coiled on a large reel, and placed in front of the Brooklyn tower. The end of this rope was then hoisted to the top of the tower, carried over the roofs of the houses to the anchorage, and there made fast. The reel with the balance of the rope was placed on a scow and towed over the river to the New York tower, the rope unwinding off the reel and sinking to the bottom of the river. When the scow reached New York, the remainder of the rope was unwound, and the end carried over the top of the tower precisely as in Brooklyn, and by means of the engine the slack of the rope was hauled in, and the rope lifted to its place between the towers.

The first rope thus extended between New York and Brooklyn was called the traveler-rope, and afterward played an important part in the work of stretching the wire of the cable. A second rope was taken over in like manner, and the ends of the two spliced together, so as to make an endless belt, like the band on a sewing-machine. On the two anchorages a series of pulleys had been placed, connected with steam power; as soon as the traveler was spliced it was placed around the pulleys, the engine started, and the rope began to move, running smoothly and quietly through the air, an enormous belt, 7,000 feet long. When the rope was in good working order a "Bosun's chair," consisting of a bit of plank suspended by four ropes, was attached to the traveler, in which the master-mechanic of the bridge took his seat, and was swiftly hauled from New York to Brooklyn, thus making the first trip over the bridge.

Four other ropes of larger size were now quickly stretched from New York to Brooklyn, and on these a substantial platform of oak slats laid, two smaller ropes added, stretched at a height convenient to serve as a handrail, and the foot-bridge was complete. Our picture (see page 13), taken from the top of the Brooklyn tower, gives a perfect representation of the foot-bridge. Such a structure, spanning the river at such a height, looks as frail as a spider's web; yet even in the highest winds the bridge scarcely



THE NEW YORK APPROACH—EASTWARD FROM THE CITY HALL.

swayed, and during all the six years that the bridge remained in place not a single accident occurred on it.

The roadway of the great bridge is so wide that it was necessary to support it by four cables, two placed near the centre and one on each side. These centre cables are nearly 100 feet apart, and so, to give access to them at the five points above mentioned, it was necessary to build five little bridges, called cradles, extending transversely across the span, and connecting with the foot-bridge. In the illustration will be seen three of these cradles, placed in the centre span, and with their completion the preparations for cable-making were finished.

As fast as the wire was received from the factory two coats of linseed oil were applied to it, and the wire allowed to dry thoroughly. This oil served a double purpose of giving an additional protection against the weather, and by its stickiness helping to cement together the wires when they should be compacted in the cable. As soon as the oil was dry the coils were sent to the top of the anchorage, and were ready to be spliced. Each coil was about 800 feet long, and as the distance over the entire bridge, from anchorage to anchorage, was more than 3,500 feet, it required at least four rings to make a single wire extending from New York to Brooklyn. It was essential to make the splices so as to preserve as far as possible the full strength of the wire. After much experimenting it was found best to cut a right-hand screw thread on one end of each coil, and a left-hand thread on the other; then the ends of two coils to be spliced could be screwed into a little steel sleeve, or coupling, in the same manner that gas or water-pipe is joined; and by making the screw threads of a peculiar shape, it was found possible to preserve ninety-seven per cent. of the full strength of the wire. As far as strength was concerned, this method made a joint very nearly perfect, yet when the first wires were sent over much trouble unexpectedly arose from the unscrewing of the splices and the dropping of the wire into the river. To remedy this difficulty the ends of the wire were scarfed, so that when the coupling was screwed on, one end lapped over the other, and made a locked joint which it was impossible to unscrew without breaking the wire. After the coupling was screwed home the whole joint was dipped in a ladle of melted zinc, to galvanize it and seal it up water-tight. All the details of this splice may be well understood by reference to a picture of the wire splice.

At the top of the illustration is seen the little coupling, and just beneath a sample of the wire. Next in order come the two ends of the coils, with the right and left threads, all ready to screw into a coupling. The next sample is that of a joint cut open, so as to show the wire in the centre, with the scarfed ends partially lapped by each other; while the last figure gives the completed joint after it has been galvanized, and is all ready to send out into the cable. So perfect a splice did this make that out of the 120,000 sent into the cable, only one that had been rightly made was found imperfect. A glance at the picture of "drumming up" will show the final operations of splicing the wire, and winding it on the large reels preparatory to sending it out into the cable.

For convenience in building, each cable was divided into nineteen strands, each consisting of about 300 wires. In describing the anchorage it will be remembered that a long chain of iron bars was built into the masonry. On the top of the anchorage this chain spreads out into nineteen pairs of bars, one for each strand. The operation of cable building was commenced by pulling out one end of the wire from off the drum in the anchorage, and securing it to a horse-shaped piece of cast iron, placed on one of the anchor bars, and called a shoe; the loop thus formed in the wire was passed around a large wheel or sheave placed on the traveler-rope. The engine was then started, and the rope, wheel and wire were hauled to New York. As fast as the sheave was carried along the wire was pulled off the drum, and running around the sheave, hung down in the air; on arriving at the New York anchorage the loop of wire was taken off the sheave and passed around a similar shoe there placed on a corresponding set of anchor-bars. The traveler-rope was then hauled back to Brooklyn and was ready to start with a second load of wire. This operation was repeated till the requisite number of wires was laid to make up a strand the wire was then cut at the drum, and the end spliced into the first end on the shoe, and the completed strand hung between New York and Brooklyn, an enormous skein of steel yarn wound from anchorage to anchorage.

As soon as completed the strand was lashed at intervals of a few feet, to keep the wires in place and prevent them from becoming entangled with the wire of succeeding strands; and then, by means of very powerful blocks and falls, the shoe was gently let forward, and secured in its final place between the anchor bars with a pin. On the tops of the towers there are four large castings resting on rollers, and called saddles; they are intended to support the cables, and prevent the wire from coming in contact with the masonry, and the last operation on the strand consisted in lowering it into its place in the saddle. Strand after strand was thus built, until, after eighteen months of patient labor, all the wire was in place. Then came the operation of winding, or "serving" the cable with a continuous wrapping of wire, extending from anchorage to anchorage, round and round the cable, like thread on a spool. By means of this "serving" all the wire of the cable was compacted together, and the loose, swinging threads of steel converted into a solid cylinder, and the work of cable-making finished.

Although in a suspension bridge the cables are the real support, it is impracticable to form the roadway by laying timbers or planks directly across them, as would seem to be the natural course, for the reason that, in order to secure strength, the cables must be allowed to hang in a curve, the inclination of which, between the centre and either tower, is far too steep to be traveled. The mode adopted is to suspend the beams which underlie the roadway at some distance beneath the cables, by means of steel rods or wire ropes, and to lay an appropriate flooring on these beams, constructed conveniently for the actual walks and carriage ways.

In the construction of the East River Bridge each cable is furnished with a number of wrought iron bands, placed seven and a half feet apart. Each of these bands is fitted on the under side with two projections, technically called "ears," through which passes a large iron bolt, serving the double purpose of drawing the band tightly together, by which it is secured to the cable, and of providing a convenient means of attaching to the cable the ropes or rods that are to sustain the floor. Midway across the river, where the descending curvature of the cables brings them down quite close to the roadway, the suspenders are made of steel rods, having at one end an eye, through which the bolt of the cable-band passes, while the other end is equipped with a screw thread and nut, by means of which it is secured to the end of the floor-beam. Near the tower, where the cables rise to more than 100 feet above the floor—a distance much too great to admit the convenient use of rods—the suspenders are made of steel wire rope.

In order to fasten the rope to the cable an iron forging, shaped somewhat like a pail with the bottom knocked out, and called a "socket," is employed. Through the place in the socket where, if it were a pail, the bottom would be, the end of the rope is passed, and the wires forming the rope are untwisted, and spread out so as to occupy as much space as possible; a number of iron wedges are next driven in among the wires, and at last the remaining space is filled completely by pouring in melted lead; the whole forming the strongest possible fastening, and one which has been repeatedly tested to the point of breaking the rope, without eliciting any indication of failure. The cable-band pin is passed through the bail of the socket, while the lower end is secured to the floor-beam by two bolts passing through a cast-iron socket of somewhat similar description.

In addition to the suspenders there are on each side of the towers a series of wire ropes forming, as it were, little supplementary cables. These ropes extend from the top of the towers to the roadway of the bridge on either side, and very materially help to support that portion of the bridge which is next to the towers.

The floorway proper consists of long beams or girders, laid crossways to the cables—that is, at right angles to the line of the bridge—and of a layer of timber and other materials of the roadway upon these timbers. In addition to the floor beams there are six lines of steel trusses extending from one anchorage to the other. The primary object of these trusses is to stiffen the bridge, thus preventing the oscillation and vibration which have made suspension bridges disagreeable, and have in some cases led to their destruction.

In order that the flooring may be both light and strong, steel was chosen as the material. It was made in lots of about six tons each, and by way of testing its strength and quality, a sample of each lot was rolled to a bar an inch square, the two ends of which are gripped in a powerful hydraulic testing machine, which pulls the bar lengthwise until it is absolutely pulled in two, while indices note how much the bar stretched, as well as how much force is exerted in finally breaking it. Unless the material required at least 75,000 pounds to the square inch to break it, and would, before breaking, stretch at least fifteen per cent., it was rejected. A sample bar having passed the test, the steel "blooms," as the raw stock is called, were heated and rolled into useful shapes, such as eye beams, channel bars, angles and rods round or square. These were then subjected to some further finishing operations; in fact, the material made four railway journeys, and passed through three of the largest shops in the country, between the first making of the steel and its final destination in the bridge.

Each of the floor beams, hanging from the cables by its suspenders, is itself a little bridge, being eighty-six feet long and thirty inches deep, and consisting of two long straight bars of steel connected by many cross bars. Experience has shown that this mode of construction obtains the greatest strength with the least weight. Between each floor beam six small steel frames are placed, which serve the purpose of accurately spacing the distances between the different beams, and are technically known as bridging trusses. On each floor beam stands a steel post, about ten feet high for the outer trusses, and eighteen feet for the inner ones; and steel channel bars extend from post to post at top and bottom, forming what are technically known as the upper and lower chords; while a series of strong steel links runs diagonally from the top of each post to the bottom of its neighbor on either side. The entire system thus forms a very stiff lattice-work, extending between the anchorages, and which may be trusted to prevent vibration.

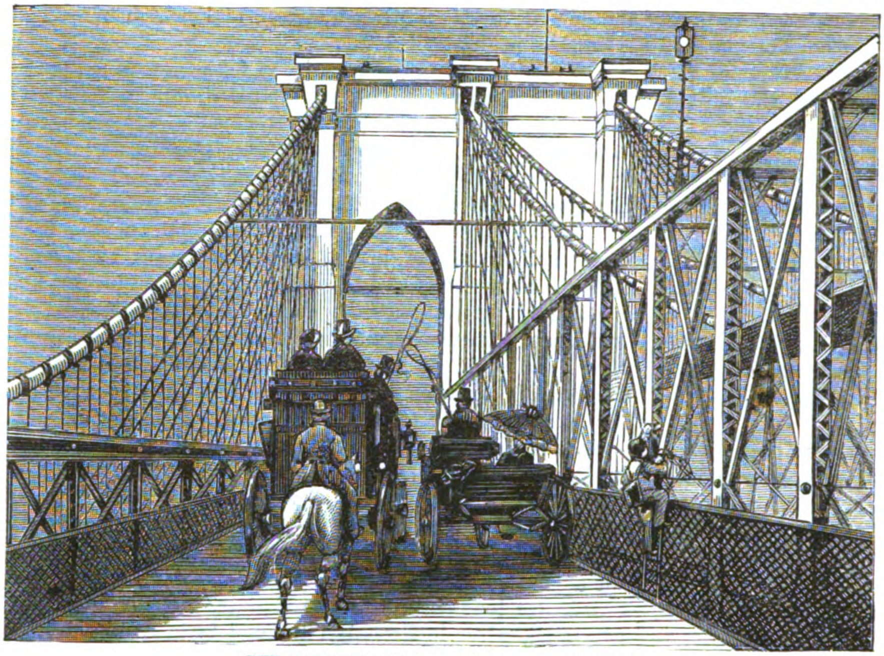
The roadway embraces a pathway for pedestrians, "the promenade" along the centre of the bridge, tracks for steam cars on either side of the promenade—one track for cars going each way—and tracks for vehicles—"tramways"—lying beyond the steam car tracks, and nearest the edges of the bridge. The trusses will distinctly separate these five ways. The promenade, which sustains the same relation to the bridge as the sidewalk to a city street, is about five feet higher than the general level, and is carefully prepared for the convenience of pedestrians. A Summer morning walk or a moonlight saunter from New York to Brooklyn to view the river and margins of the two cities from an elevation of 150 feet, are among the luxuries now ready for the good people of the two cities.

On either side of the river the suspended portion of the bridge ends at the anchorages. The tops of these massive piles of stone are eighty feet above the street level; hence to render easy access to the bridge, two long inclined planes, or approaches, have been built, extending from the anchorages to the street. In New York the approach terminates in Printing House Square, just opposite the City Hall, while in Brooklyn the end is in Sands Street, just off of Fulton. The New York approach is the longest and largest, for the reason that the surface of the land, instead of rising as it recedes from the river, as is the case in Brooklyn, actually sinks, and in the swamp is lower than at the water level.

The accompanying illustrations represent very completely both the New York and Brooklyn approaches, as will be seen. Each structure consists of massive walls of masonry, supporting the roadway which gradually rises from the street level to the bridge at the anchorages. Of course the land thus occupied is very valuable, and in order to preserve as far as possible its usefulness, the approaches are built of a series of arches. Between the piers of these arches it is proposed to extend fireproof floors, thus converting each approach into an immense building, which may be used with perfect safety for storing the most valuable goods, as it will be as nearly perfectly fireproof as it is possible to make any structure, for from the absence of combustible materials used in its construction, it can never burn of itself, and its immense size will successfully resist attacks of fire from without.

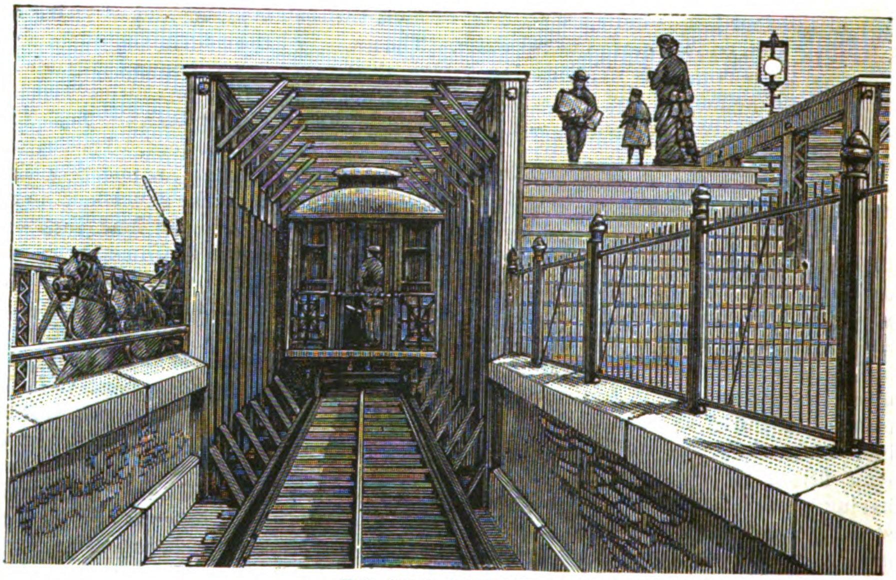
In order to obviate the interruption of street traffic, the approach, wherever it crosses a street, is carried on a short bridge; thus at Prospect and York Streets, in Brooklyn, may be seen some very fine examples of plate girders, while the truss bridge over Franklin Square, in New York, would, were it not lost in comparison with the main span of the great bridge, be considered quite a bridge of itself. All the masonry of the approaches is composed of brick, not laid in ordinary mortar, but in cement, and in the most substantial manner. The faces of all the walls, the abutments, and the arches, are constructed of New England granite, in the most massive and durable manner, and yet with so pleasing an architectural effect, that when the poorer buildings which now conceal the work disappear, as soon they must, the bridge will present an appearance not to be paralleled in the country.

Of course, to the public, the most interesting question is, How can I cross the bridge? Three ways are presented. First, you can walk. Commencing at the approach, let us say at Sands Street, Brooklyn, we pass under a large iron building devoted to a car station, and emerge on a broad, smoothly concreted walk, that, gently inclining upward, leads us out over the approach toward



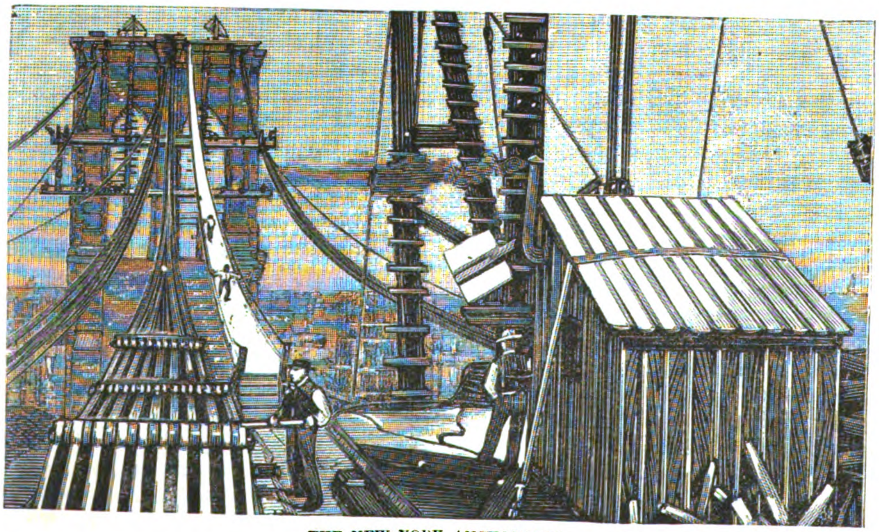
THE ROADWAY ON THE EAST RIVER BRIDGE.

the anchorage. Gradually, as we walk onward, we find ourselves rising above the house-tops, and, scarcely noticing it, we cross the bridges at York and Prospect Streets, and find ourselves on the anchorage, ready to commence the actual trip over the river. So far, the walk has certainly not been very terrifying, for we have been on a broad sidewalk, wider than either Broadway or Fifth Avenue, and guarded on either side by a substantial iron railing. Beyond the railing are the divisions of the roadway set apart for the cars and carriages. As we leave the anchorage the fact of being on a bridge is scarcely more apparent than on the approach. The same sidewalk still continues, with its railing, and the carts and cars on either hand. Now, however, we see the ponderous steel trusses of the bridge itself, and soon the great steel cables with their network of suspenders and stays rise before us. We fail to see even the tops of the taller chimneys any more, and as we pass around the shaft of the tower we see the broad bay stretching to the south, while all around and under us the busy ferry-boats are darting about, and with their shrill whistles screaming to each other to keep out of the way. By degrees the ascent becomes more gradual, and here, on a level spot, we stand at the centre of the bridge and look either way down the incline.



THE RAILROAD TRACK.

The grand view of the bay can be much better obtained by a walk over the bridge than in any other way, yet after the first novelty has passed, most people will prefer to pay five cents and be quickly whirled over in a car, occupying but two or three minutes, than to spend the time and be subject to the fatigue of the walk. On either side of the promenade extend two divisions of the roadway, intended for cars propelled by wire rope. The grade of the bridge is so steep that to draw trains of cars by locomotives would require exceedingly heavy engines, and the annoyance to pedestrians from the smoke and cinders, and the danger of frightening horses on the roadway, are so great, that

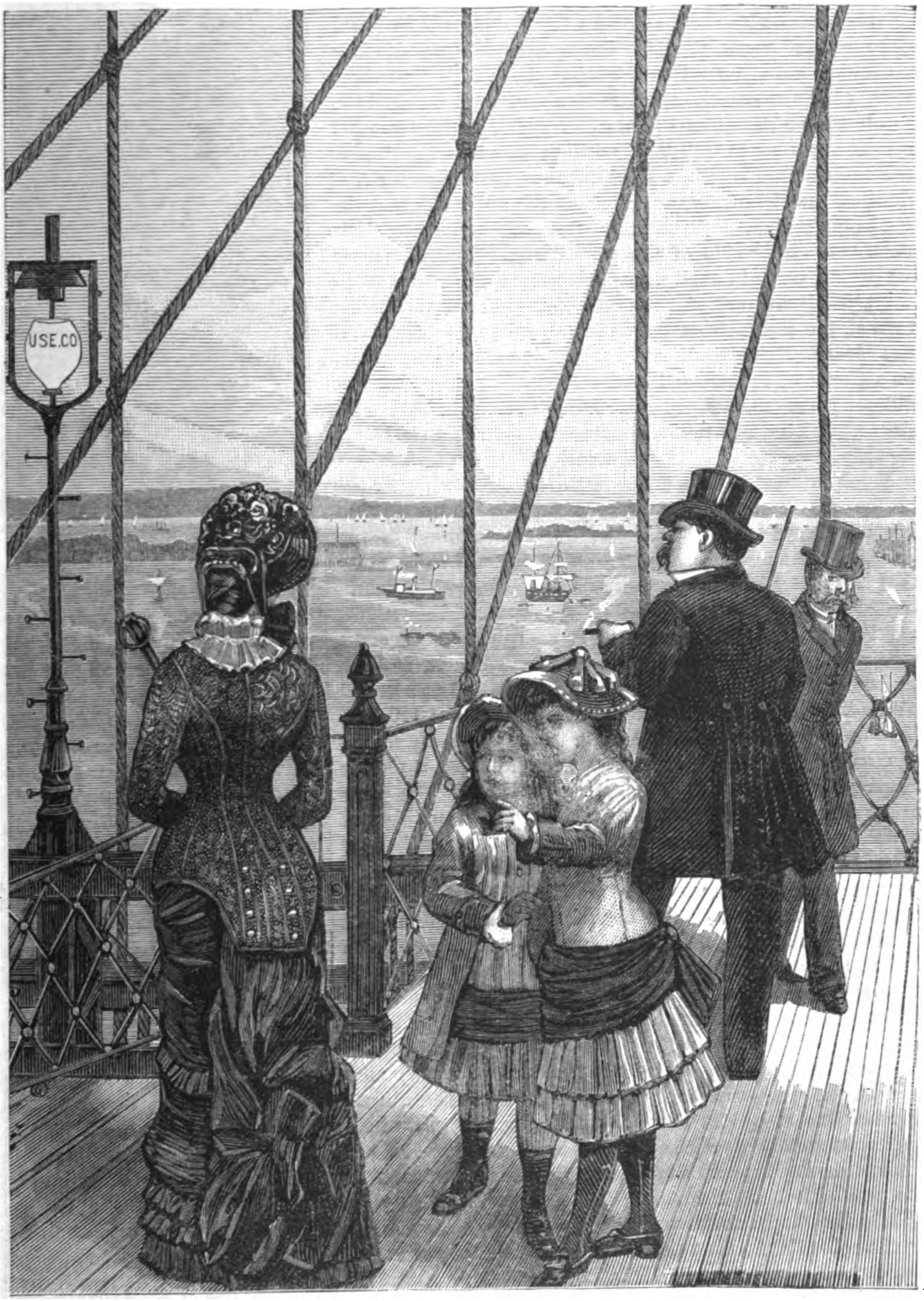


THE NEW YORK ANCHORAGES.

the method of wire-rope propulsion is deemed the best for the bridge. Near the end of the Brooklyn approach are situated two large engines, one of which is used to drive the rope, while the other is kept in reserve in case of accident to the first. Between each car-track extends a long iron trough in which, supported on a series of wheels or rollers, runs the endless rope, being a great band passing from New York to Brooklyn. On the Brooklyn side the rope passes around some large wheels that are turned by the engine. Then the rope runs along one side of the bridge to the New York anchorage, where, by means of two large guiding-sheaves, it is led to the other side of the bridge, and then returns to Brooklyn. Each car is supplied with a very ingenious grip or clutch, something like a mechanical hand. It consists of a series of rollers that embrace the rope, and turn round with it. When it is desired to start the car, a brake is so applied to these rollers as to very gradually stop their motion, and just in proportion as the wheels are stopped the motion is communicated to the car, which starts, and moving with increasing speed along the track, soon acquires the full speed of the rope, without the slightest jar or shock to the occupants.

By gradually releasing the brakes the car can at any time be stopped in the most gentle manner. In such a case as the East River Bridge, where the cars have a track devoted entirely to themselves, there is scarcely a limit to the speed at which the cars may be driven, so that it is expected that twenty or thirty miles an hour will be a common speed for transit. The entire time occupied in running from Sands Street, in Brooklyn, to the City Hall, in New York, will not occupy more than three or four minutes. In the busy portions of the day it is the intention to start a car as often as once a minute, and by combining several cars in a train it will be perfectly easy to transport 10,000 or more people an hour. This, certainly, will be far less hazardous, and infinitely more comfortable, than the present dangerously crowded passages of the ferry-boats. A similar method of wire-rope propulsion has for some time been employed in San Francisco and Chicago, with the most marked success.

There is still one more way of crossing the bridge, which, it is probable, will be preferred by the ladies, especially on the pleasant afternoons of Spring and Fall; that is the way of riding over the driveway in one's own carriage. In the outermost division of the roadway, separated on the one hand from the car-track, and guarded from the edge on the other by high trusses, lies the carriage-way, than which a finer drive can scarcely be imagined; so that in a year or two it may be expected that even the boulevards of Paris will scarcely parallel the drive over the East River Bridge.

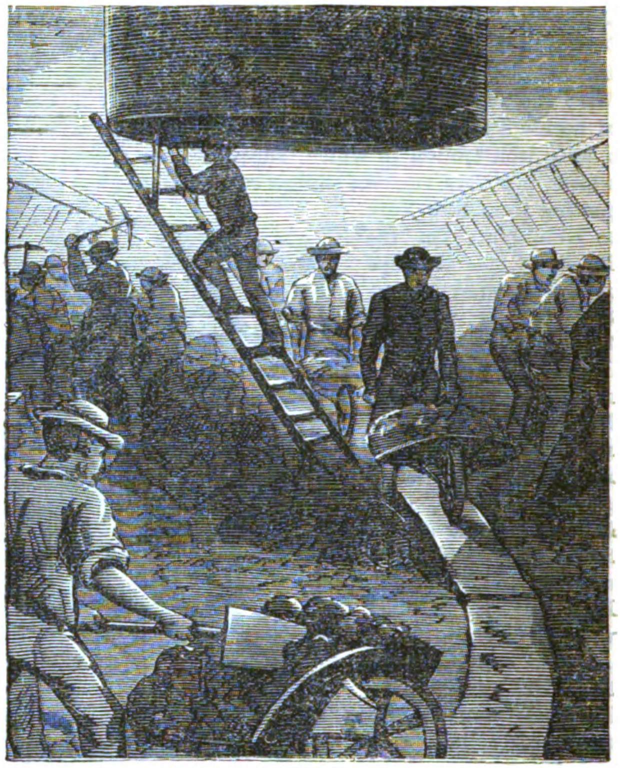


THE TOWER PROMENADE.

The long delay in the completion of the bridge has doubtless been vexatious, not only to the public, but equally to those having the matter in charge. Yet, according to the old saying, there is no loss without some gain; and so, while the cities have been patiently waiting for the completion of the structure, science has so far advanced that now it is possible to have the whole roadway so brilliantly lighted with electricity as to make the night trip rival, if possible, the day experience. In the same engine-house with the machinery for driving the cars, the appropriate engines, with the corresponding dynamo machines, are arranged for lighting the bridge; all those parts of the apparatus that are likely to wear are made in duplicate, so that if one part gives out or breaks another can at once be substituted, without any interruption to the lighting. From the engine-house the wires for conducting the electricity extend along the approach and the roadway, and pass into lamps that are arranged alternately on either side of the promenade. The lamps are set on tall posts in such a way as to flood the entire roadway with light, and at the same time prevent the direct rays of the lights from dazzling the eyes of pedestrians. For electric lights the East River Bridge is a trying place, on account of its exposed situation, and to guard against difficulty on this score the lamps are provided with shields, to keep out rain and snow and maintain the lights steadily, in spite of wind and weather.

Much interest has been felt in the question whether the bridge will not become an obstruction to navigation beneath it. The permission of the Government to the building of the structure was granted upon the condition that the centre of the span should rise at least 135 feet in the clear above the surface of the water. The actual making of such measurements is complicated by some scientific considerations; thus a measurement at high water is intended, the space which is afforded to a vessel which selects the hour of low water will be about 140 feet. In Winter weather the contraction of the cables by reason of the cold will raise the roadway, and add another foot or more. Very few vessels navigating the East River carry masts that are more than 135 feet in height—probably not more than one in a dozen or fifteen—and those that do carry taller masts will be able to avoid difficulty by lowering the topgallant mast before reaching the bridge on the way to port and delaying to hoist it when outward bound until the bridge is passed. A few years will demonstrate that the opposition from ship and dock owners, which has been so large a factor in the delays to the completion of the bridge arose, like all such opposition, from people who had a particular ax of their own to grind.

The East River Bridge is done; and now the very men who for ten years past have been growling at the enormous expenditure of public money, exclaiming that the whole affair was merely a political job to enrich a corrupt ring of contractors, and predicting disaster to the commerce of the two cities, are thronging the roadway, admiring its wide drives and smooth walks, congratulating each other on the splendid facilities afforded for transit between New York and Brooklyn, and felicitating themselves on the increased value that the bridge gives to their property. In our enthusiastic reception of the bridge as the crowning piece of American engineering let us not forget the men to whose patient and indomitable energy we owe the successful completion of the work, men who for the past ten years have given their very life to the undertaking; who have toiled in the mud and slime of the river, exposed to the dangers of compressed air, worked amid the granite and mortar of the growing tower, and swung at dizzy heights over the river, suspended on a single thread of steel. The



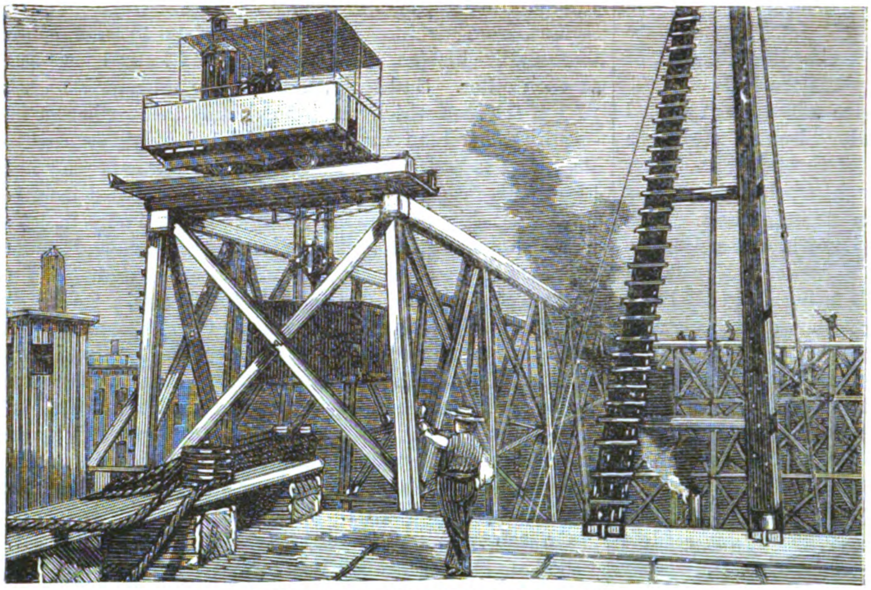
THE INTERIOR OF THE CAISSON.

East River Bridge is finished, and as New York and Brooklyn shake hands at the centre, no longer separated by the broad estuary, let there be mingled with the rejoicing a shade of sadness that Mr. John A. Roebling, the designer, to whose mighty brain America owes not only the East River Bridge, but also those at Niagara, Pittsburg and Cincinnati, did not live to see this last and crowning conception realized; but, falling a victim to the first mischance on the work, bequeathed our bridge to his son, whose zeal and fidelity, despite continued ill health, have made the East River Bridge the greatest feat of engineering in the world.

The opening of the East River Bridge, on the 24th of May, 1883, was one of the greatest spectacles for both cities. The cities were in many parts elaborately decorated, and thousands of spectators flocked in by every means of conveyance. Shortly after noon President Arthur, Governor Cleveland, and other distinguished guests were escorted by the Seventh Regiment to the bridge, on which they were met by the Brooklyn city officials. Salutes were fired by Government vessels and the forts in the harbor, while the Presidential party was crossing the river.

The formal exercises were held on the Brooklyn side. Bishop Littlejohn offered prayer, after which Vice-President Kingsley, of the Bridge Trustees, presented the structure to the cities, and it was received by Mayor Edson for New York and Mayor Low for Brooklyn. Orations were then delivered by the Hon. A. S. Hewitt, in behalf of New York, and the Rev. Dr. Richard S. Storrs, for Brooklyn.

In the evening a splendid display of fireworks was made from the towers and the centre of the bridge, which was witnessed by immense crowds, and were visible over a large extent of country in both Long Island and New Jersey. The President and Governor, after dining with Mayor Low, held a reception at the Brooklyn Academy of Music. The bridge was thrown open for traffic shortly before midnight.

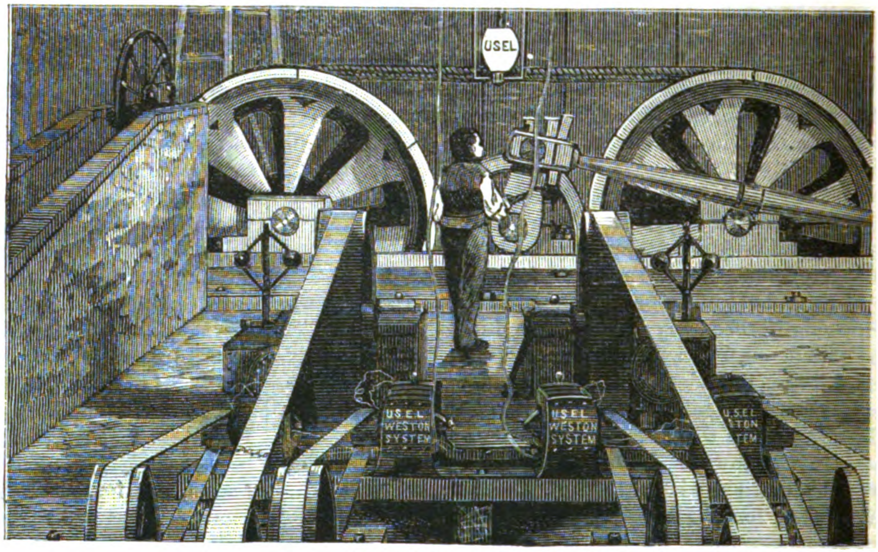


LAYING THE APPROACHES TO THE BRIDGE.

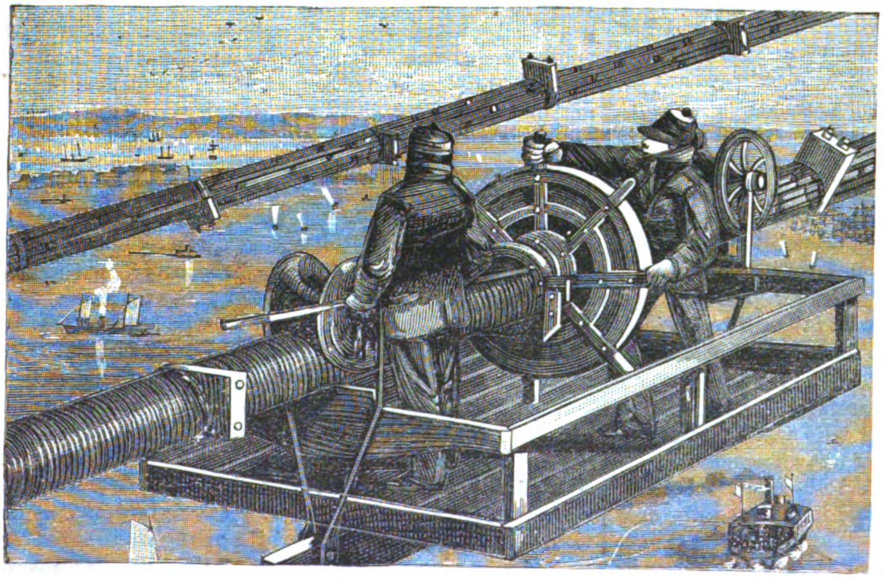
Under the pressure of such feelings, it may readily be imagined that I lost but little time before calling on Phillips and his wife. I found the latter at home, and what she had to say only made me more uncomfortable still. James Henry Phillips bore such a close resemblance to his father, that all who saw him remarked on the striking likeness. In addition to this, during the last three months of his life, which he spent under his father's roof, he had often wondered that I did not come to see him. His longing for an interview with me had been most intense; and every time he saw me pass the house without going in, he had both felt and expressed a keen disappointment. In fact, he died terribly in earnest, wishing in vain to the last that I would come. The thought pierced me through and through. I had not gone to him, but he had come to me. And yet I would have gone, if I had but known. I blame the doctor for not telling me; I blame the parents for not sending for me; and with that awful look he gave me in my remembrance, I blame myself, though I cannot tell why.

But there is something else I have to tell in order to make this sad short story complete. James Henry Phillips had died on the Thursday before the Sunday on which I had seen him. He had died, too, in the front room, on a

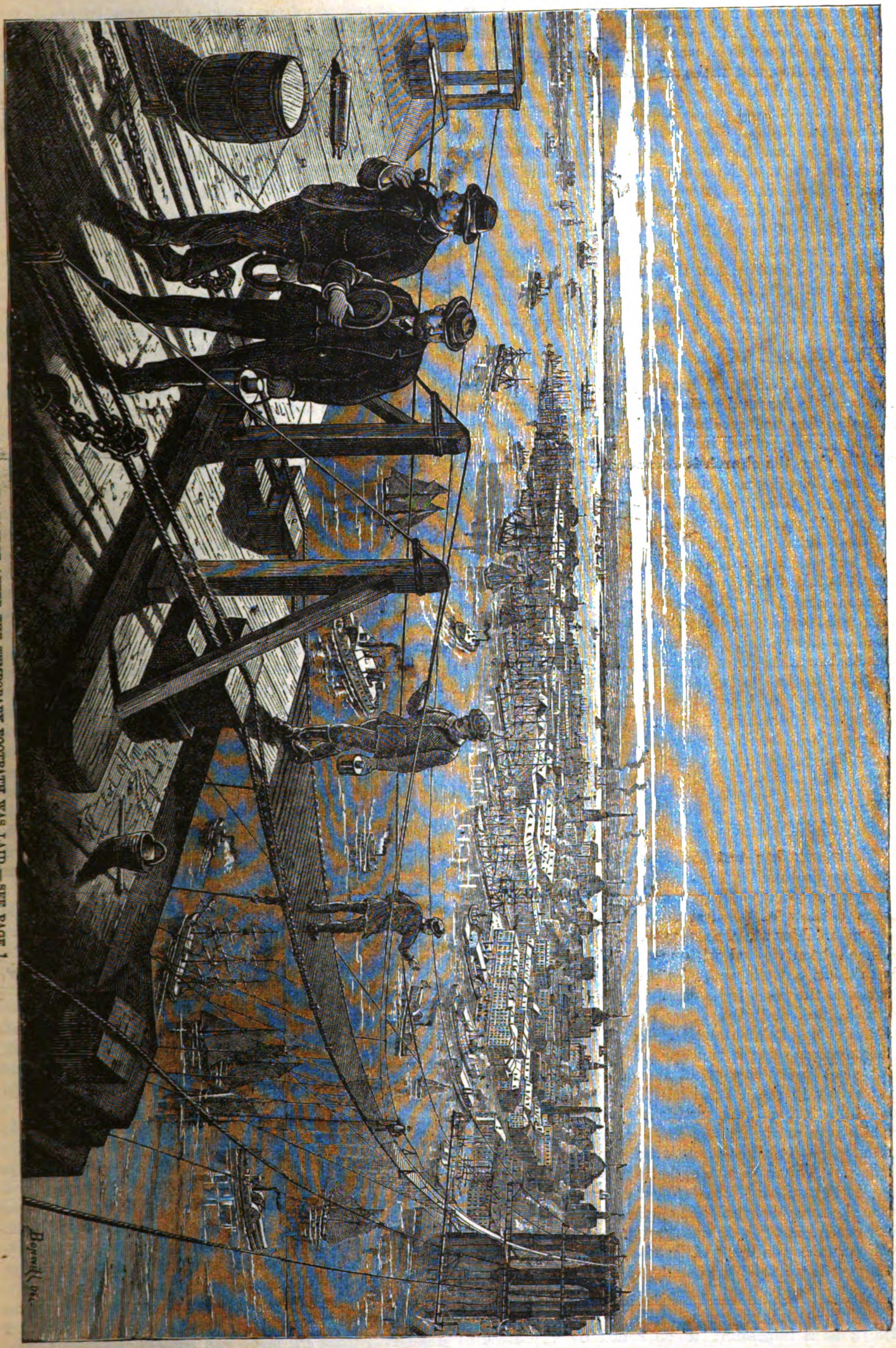
the victim of my own imagination, building up unnecessary horrors out of a chance coincidence, singular indeed, but in no sense preternatural? Had I known of his presence in the town, and yet had left him unvisited in his illness, then I could have understood the reproach and pain visible in his face, and could at once have felt that he had come to me with a message of blame from another world. Oh, how that look of his haunted me, mingling with my dreams, and disturbing my waking thoughts! Nay, to this very day, though years have passed, I cannot recall the story without a shudder and a thrill.



THE ENGINE-ROOM.



WRAPPING THE CABLES.

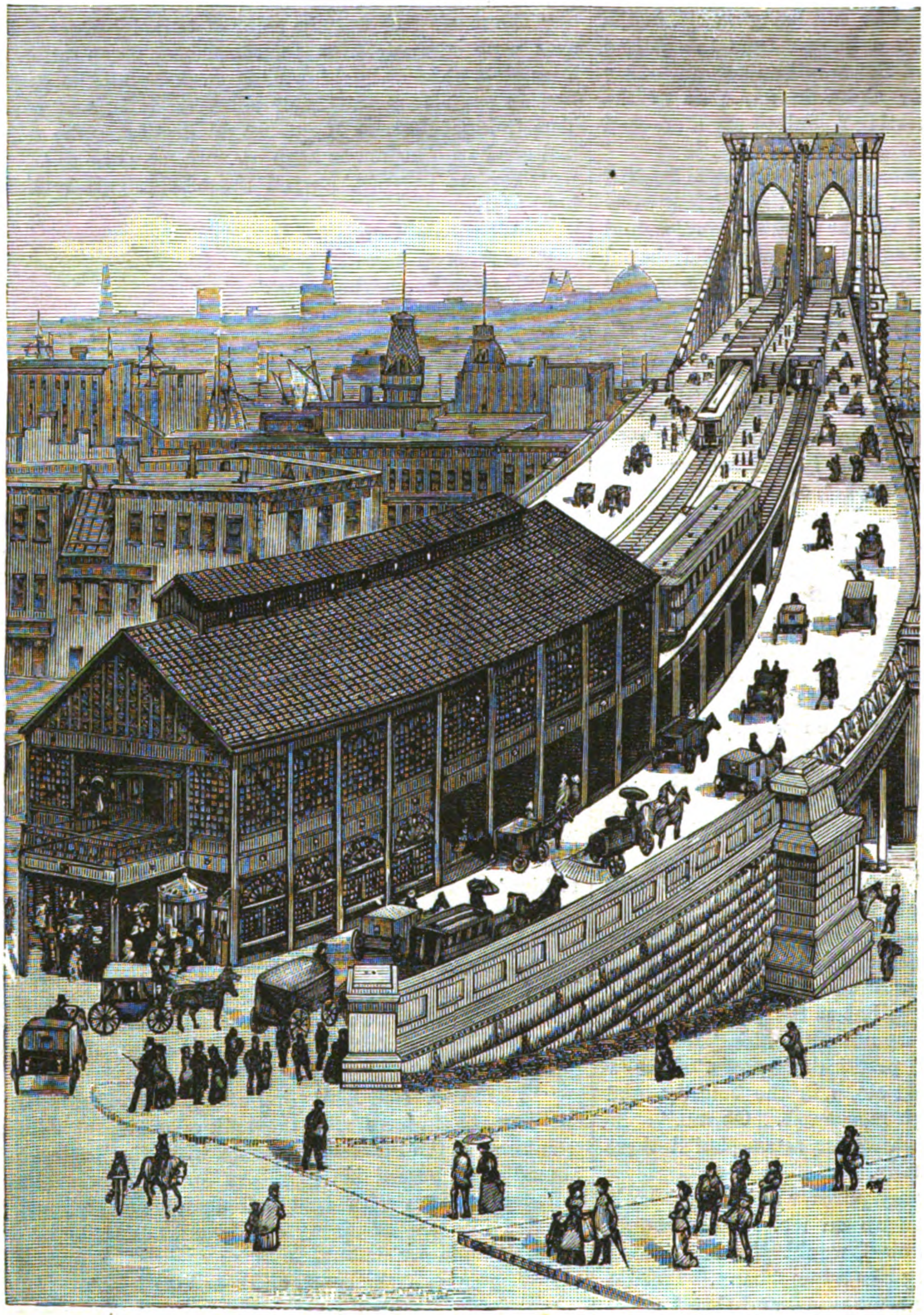


THE BROOKLYN BRIDGE AFTER THE TEMPORARY FOOTPATH WAS LAID.—SEE PAGE 1.

ladies still brandish fans, they do not occupy the same place in female economy. They are not a necessary part of the costume, even to those who array themselves in the most faded of Miss Greenaway's autumnally tinted vestures. It is still more remarkable that, though prizes have recently been offered, and an exhibition held, for designs of fans, nothing original or in any way out of the common was produced. The patronage of royalty failed to evoke a single painting which could be shown as evidence that since Addison's day taste and skill in decoration have advanced.

The writer, describing the second motion in the exercise of the fan—namely, of "unfurling"—calls it the most pleasing art of his drill to those who are looking on. "It discovers on a sudden an infinite number of cupids, garlands, altars, birds, beasts, rainbows, and like agreeable figures." Every one in the regiment held a picture in her hand, and the subject of every picture was thus clearly indicated, and the description would serve equally well to describe a modern show of "that little modish machine."

Views of gardens, in which move figures in Watteau-like costumes or none, cupids, and all the gods and goddesses predominated largely, and it was abundantly evident that none of the competitors had made the slightest attempt to strike out a new line of fan decoration, and that the best were only anxious that their productions should be the nearest possible imitation of old work.



THE LONGEST SPAN IN THE WORLD.—THE BROOKLYN APPROACH.— SEE PAGE 1.

It must be conceded that a fan is not an easy thing to decorate effectively. The folds into which it falls are so stiff that a picture is spoilt, and cannot be properly displayed even when the fan is new. Landscapes and other scenes are all very well on Japanese stiff hand-screens; but on folding fans they are out of place, and the wonder is that modern designers do not endeavor by some device, which it is not our business to invent for them, to make the beauty of a fan consist in the way the picture is adapted to the conditions; or, as a Gothic architect used to say, to render the construction ornamental. A handsomely painted fan is a thing to hang up, not to use. It is not made to go into folds without risk of ruin. It is not, in short, properly a fan, but a picture. There is something wrong here. Fans are infinitely little subjects for the display of high art; but no doubt something might be done, "provided a woman applies her thoughts to it." Ten years ago foreign manufacturers supplied us with all our fans, but now, with the exception of the more expensive and highly artistic kinds, their manufacture has become quite a prominent industry in this country.

THE maximum of life can only be reached by the maximum of virtue.